Practice Problems in Physics

Set 1

Topic: Thermal Expansion

1. A steel beam in a bridge extends 25m across a small stream. What is the change in length from the winter, when its temperature is -20oC, to the summer, when it is 38oC? The coefficient of linear expansion of steel is 12 x 10-6/oC. (ans. 1.7cm)
2. The aluminum lid of a jar of pickles is stuck to the jar. To loosen the lid so it can be opened, hot water is poured over the lid, causing it to expand. If the temperature increase of the lid and of the glass is 400 C, calculate the change in circumference of the lid and of the glass which it is screwed. The diameter of the lid before heating is 22cm and the coefficient s of thermal expansion for the aluminum and the glass are 25 x 10-6/0C and 10 x 10-6/0C respectively. (ans. 0.69mm and 0.28mm)
3. During a summer night when the temperature is 200C, your house contains 453m3 of air. What volume of air leaves the house through an open window if the air warms to 400C on a very hot summer day? Assume that the dimensions of the house experience negligible change and that all other conditions are constant. The coefficient of volume expansion is 3670 x 10-6/0C. (ans. 33m3)
4. Two concrete roadway slabs 25m long are accidentally laid without expansion gaps. How high will the slab buckle up if their temperature increases from 100C to 500C if the volume coefficient of thermal expansion for concrete is 30 x 10-6/0C? (ans. 0.71m)

Topic: Quantity of Heat

1. You wish to take a bath and will need to warm 160kg of water by 140C. How much heat is required? (ans. 9.4 x 106 J)
2. A person will die if his or her body core cools from 370C to about 310C. Calculate the heat that must be removed from the body of a 70kg person to cause this temperature change. The specific heat capacity of the human body is around 3470 J/kg-oC. (ans. 1.5 x 106J)
3. A 5-g lead bullet travelling at 300m/s penetrates a wooden block and stops. If 50% of the initial kinetic energy of the bullet is converted into thermal energy of the bullet, by how much does its temperature increase. The specific heat capacity of lead is 130 J/kg-0C. (ans. 1700C)

Topic: Phase Change

1. The 1.0 x 107 kg of ice in a small pond has an average temperature of -50c during the middle of the winter. How much heat must be added to the ice to convert is to water at 270C for summer swimming? The latent heat of fusion of ice id 3.35 x10 5 J/kg and the specific heat capacities of ice and water are 2090 J/kg-0C and 4180 J/kg-0C respectively. (ans. 46 x 1011 J)
2. How much heat is required to evaporate 20g of ethanol if its latent heat of fusion is 8.5 x10 5 J/kg? (ans. 1.7 x10 4 J)
3. A woman carrying a 15-kg pack on a hike in the desert sun evaporates perspiration at a rate of about 0.28g/s. Estimate the rate at which heat must be transferred out of her body to the liquid so that it can evaporate at this rate. At the surface temperature of the skin, the heat of vaporization of perspiration is 2.4 x 106 J/kg. (ans. 670W)
4. An enclosed insulated container holds 50 g of ethanol. To this 50,000 J of heat is transferred. Calculate the final state and temperature of the ethanol if it is initially at 280C. The heat capacity of ethanol in its gaseous state is 1800 J/kg-0C. (ans. 900C)
5. A kettle containing 0.75kg of boiling water absorbs heat from a gas stove at a rate of 600J/s. How much time is required for the water to boil away? Assume that the heat of vaporization of water is 2.256 x 106 J/kg. (ans. 47min)

Topic: Calorimetry

1. An insulated aluminum can whose mass is 0.20kg contains 0.30kg water at 250C. A 0.10kg metal block whose temperature is 800C is lowered into the water. The final temperature of the water, can and block is 300C. What is the specific heat of the metal block? (ans. 1430 J/kg-0C)
2. Ten grams of ice at 00C is placed in a Styrofoam cup containing 300g of coffee initially at 900C. Calculate the final temperature of the coffee after all the ice has melted. Assume that no heat leaves the Styrofoam cup. The specific heat capacity of coffee is the same as that of water. (ans. 850C)
3. A 300-g aluminum calorimeter holds 150 g of water. The water and the aluminum are initially at 30oC; 200 g of ethanol at 550C is added to the water. Calculate the final temperature of the mixture. The specific heat capacity of liquid ethanol is 3800 J/kg-0C. (ans. 38.90C)
4. To 200g of coffee (essentially water) at a temperature of 700C in an insulated cup, 25g of milk has been added at 100C. If the specific heat capacity of milk is 2480 J/kg-0C, how much is the coffee temperature lowered when the milk is added. Neglect the presence of the cup. (ans. 6.10C)
5. An insulated bowl containing 0.20 kg of soup at 400C is cooled to 200C by adding water. Calculate the mass of water that must be added so that the mixture has a final temperature of 340C. Ignore the heat transfer to the bowl. The heat capacity of the soup is 3800 J/kg-0C. (ans. 0.078kg).